<u>Amendments to the Specification</u>

Please amend the specification as follows:

Please amend the title as follows.

APPARATUS AND METHOD FOR REPRODUCING INFORMATION FROM TWO TYPES OF OPTICAL DISKS <u>HAVING DISCRIMINATION MARKS FORMED ALONG TRACKS THEREOF</u>

Please insert the following paragraph at page 1, between lines 2 and 4:

This application is a divisional application of Serial No. 09/610,364, filed July 5, 2000.

Please amend the paragraph beginning at page 1, line 12, as follows:

Recently, DVDs (digital video disks) for providing high quality ~~of~~ digital ~~picture~~ <u>pictures</u> and audio sound and optical disk drives or players for reproducing DVDs become very popular. The popularity of DVD players is ascribed to the high quality of DVDs, but it is also ascribed largely to the compatibility with previous media, that is, assurance to reproduce compact disks.

Please amend the paragraph beginning at page 1, line 19, as follows:

It seems easy at first to reproduce an optical disk of low recording density (for example<u>,</u> compact disk (CD)) in an optical disk drive for an optical disk of high recording density (for example<u>,</u> DVD). However, pit marks formed on an optical disk are designed to be optimum for a shape of a laser beam spot which illuminates the pit marks. Therefore, various problems have to be solved even for reproducing an optical disk of low recording density which deviates from the optimum conditions.

Please amend the paragraph beginning at page 2, line 3, as follows:

As a most typical example, so-called mirror phenomenon occurs when recording pits of low density are reproduced with a very small laser beam spot emitted from a pickup for high resolution. Digital visual and audio information is formed on an optical disk (for example, compact disk) as pits formed unevenly, while a film (for example, made of aluminum or gold) of the same reflectance is

deposited on all of the plane thereof, irrespectively of the pits. Even if the reflectance is the same, information can be obtained by using diffraction at pit edges. Because a pit is formed to have width of about a half of a size of the laser beam spot, a part of the laser beam is diffracted at an edge of the pit so as not to enter a photodetector. However, when the pit is reproduced with a pickup of high resolution in correspondence to another optical disk (for example, DVD) of high density, because the laser beam spot is very small, almost all of the laser beam spot illuminates the inside of the pit. Thus, sufficient diffraction at the edge does not occur, and the reflected light increases. This is the so-called mirror phenomenon. It is assumed here that spherical aberration due to difference of the thickness of the substrates of two disks (for example, CD and DVD) is solved by an appropriate means.

Please amend the paragraph beginning at page 4, line 13, as follows:

In a second aspect of the invention, in three-beams canceling for an optical disk, discrimination marks are formed at predetermined constant distances, the reproduction device discriminates a first discrimination mark in a track with a first beam ~~in t~~ of he main and sub-beams and a second discrimination mark in the track with a second beam ~~in~~ of the main and sub-beams after the second beam jumps to the track. Then, a time difference when the first and second discrimination marks are discriminated is determined. Cross talk between tracks is canceled in the reproduction signals according to the determined time difference and a predetermined time difference in correspondence to the constant distance of the discrimination marks.

Please amend the paragraph beginning at page 6, line 8, as follows:

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, Fig. 1 shows an optical disk apparatus according to a first embodiment of the invention. The optical disk apparatus reproduces information from two types of optical disks of high density and low density (for example, DVD and compact disk). An optical disk 100 is rotated by a spindle motor (not shown). An optical head is composed of a laser light source 1, a grating 2, a half mirror 3, an object lens 4, a photodetector 5 and an actuator 24, and the optical head ~~it~~ is driven by a tracking controller 25 over the optical disk 100. A laser beam emitted by the laser light source 1 is divided into three by the grating 2, and the three beams enter via

the half mirror 3 to the object lens 4 to form three beam spots L0 (main spot) and L1 and L2 (sub-spots) on the optical disk 100. After these beams are reflected by the optical disk 100, they propagate again through the object lens 4 and the half mirror 3 onto the photodetector 5. The main spot L0 is divided into four by photo-elements 5a, 5b, 5c and 5d in the photodetector 5 to be outputted as electrical signals. The output electrical signals are synthesized by an adder 10 and sent via a switch 15 as reproduction signal HF to a playback section 28 which reproduces the information.

Please amend the paragraph beginning at page 9, line 4, as follows:

The beam has the elliptical shape longer only in a direction perpendicular to the tracks, so as not to decrease resolution in a direction tangential to the tracks. Therefore, when the information recorded at high density is reproduced, deterioration of the reproduced signals due to code interference from adjacent pit marks is of about the same order as the prior art. However, even if the elliptical shape satisfies the relationship of Eq. (1), deterioration of the reproduced signals may happen somewhat due to cross talk from adjacent tracks. Then, in this embodiment, in order to delete the influence of cross talk, the cross talk is canceled by using the sub-beams L1 and L2. The sub-beams L1 and L2 are located above the two adjacent tracks, and reflection lights thereof are incident on photo-elements 5e and 5f in the photodetector 5. Output signals thereof are multiplied with appropriate constants K1 and K2 by amplifiers 11 and 12 of variable gain. Then the signals are added by an adder 13, and the sum is subtracted further by a subtractor 14 from a signal due to the main beam. The result is sent via ~~a~~ the switch 15 to the playback section 28 as the reproduction signal HF. By selecting the constants appropriately, cross talk components due to the two adjacent tracks can be deleted completely in the reproduction signal HF.

Please amend the paragraph beginning at page 10, line 24, as follows:

Next, tracking error detection is explained. When information recorded at high density is reproduced, phase a difference detection technique appropriate for a medium of high density is used. That is, the reflection light of the main beam is divided by the four photo-elements 5a, 5b, 5c and 5d to be outputted as electrical signals. The output signals of diagonal pairs of the elements (the photo-elements 5a and 5c, and those 5b and. 5d) are binarized by comparators 16 and 17, and ~~the~~ a

phase comparator 6 detects the phase difference between them. The phase difference is smoothed by a low pass filter 7, and it is sent as tracking error signal TE via a switch 9 to the tracking controller 25. The tracking controller 25 moves the optical head in the radial direction and controls the tracking of the beams according to the tracking error signal TE. Further, a track jump driver 26 controls the actuator 24 for track jump of the beams.

Please amend the paragraph beginning at page 11, line 16, as follows:

The phase difference detection technique may also be used for reproducing information recorded at low density. However, when the track pitch is wider than the elliptical beam, there are cases where noises are superposed on the phase difference tracking error signal because there is an area between adjacent tracks where no signals are recorded. The comparators 16, 17 are operated with signals of noise levels in the no-signal area, so that the phase difference between the noise pulses is outputted as a false tracking error signal. In this embodiment, when signals of high density are reproduced, the sub-beams L1, L2 are used for cross talk canceling, while they are also used as sub-beams for so-called three-beams tracking error signal detection (~~Fig. 4~~Figs. A and B). That is, the output signals of the photo-elements 5e and 5f are processed by the subtractor 8 to output a difference signal as a three-beams tracking error signal. The switch 9 selects one of the phase difference tracking error signal and the three-beams tracking error signal.

Please amend the paragraph beginning at page 12, line 10, as follows:

The intensity of the sub-beams is about ten ~~percents~~ percent of that of the main beam because a signal-to-noise ratio sufficient to remove weak cross talk due to adjacent tracks can be kept. That is, when the beam of the laser light source 1 is divided by the grating 2 into sub-beams, the loss in light intensity is about 20 %, and it is smaller than the counterpart (40 - 50 %) when a hologram is used. Further, because the as-emitted elliptical laser beam ~~transmits~~ transmitted through the object lens 4, as shown in Fig. 3, decrease due to the aperture of the object lens is small, and the propagation efficiency from the light source 1 to the optical disk 100 is improved.

Please amend the paragraph beginning at page 12, line 22, as follows:

As mentioned above, three non-circular beams illuminate ~~adjacent~~ three adjacent tracks, and the cross talk canceling is performed appropriately. Then, compatibility for optical disks of different recording densities can be ensured.

Please amend the paragraph beginning at page 13, line 9, as follows:

A characteristic of the apparatus is that it can record information to an optical disk 200 with a laser pulse emitted by the light source 1 and modulated by a modulator 201. Another characteristic is that push-pull tracking error signal is used. A subtractor 19 generates so-called push-pull tracking error signal PTE from a difference ~~sum~~ of the outputs of the photo-elements 5a, 5b and that of the photo-elements 5c, 5d. Further, a subtractor 18 generates a difference signal from output signals of the photo-elements 5e and 5f for the sub-beams. Then, a ~~the~~ subtractor 20 is used to correct the push-pull tracking error signal PTE.

Please amend the paragraph beginning at page 13, line 21, as follows:

The optical disk 200 has grooves formed preliminarily as shown in Fig. 6, and information can be recorded with the laser beam while tracking a groove. In this case, the tracking error signal is detected with so-called push-pull technique wherein difference in light intensity is detected of the light diffracted at an edge in the tangential direction of the track of the groove.

Please amend the paragraph beginning at page 14, line 3, as follows:

However, in the push-pull technique, it is liable to have an offset due to an imbalance of light intensity, and it is a problem that information is not recorded at the center of the track when an off-track situation happens. For example, as shown in Fig. 6, in an optical disk wherein information has been recorded in an adjacent groove G1 and has not yet been recorded in another adjacent groove G2 and information is recorded with main beam L0 in a groove G0, imbalance of intensity of reflection light occurs due to cross talk from the two adjacent grooves. That is, the light reflected from groove G1 is darker, so that the tracking position is shifted from the track center towards the groove G2. Then, information is recorded in a position deviated eventually from the track center.

Please amend the paragraph beginning at page 14, line 17, as follows:

Then, in this embodiment, the imbalance of light intensity is corrected by using the sub-beams illuminating the grooves G1 and G2. The reflection light obtained by the sub-beam L1 scanning the groove G1 wherein information has been recorded is weaker than that obtained by the sub-beam L2 which scans the groove G2 wherein information is not recorded, so that imbalance occurs in the output of the subtractor 18. Then ~~a~~ the subtractor 20 is used to delete the imbalanced quantity from the push-pull tracking error signal PTE. Thus, the cross talk offset due to adjacent tracks in the push-pull tracking error signal obtained by the main beam is corrected by using the reflection lights of the sub-beams illuminating the adjacent tracks. Therefore, the cross talk can be cancelled regardless of recording in adjacent tracks, and the tracking error signal can be detected without offset.

Please amend the paragraph beginning at page 15, line 8, as follows:

Next, an optical disk apparatus according to a third embodiment of the invention is explained for correcting time delays between the beams. When the above-mentioned ~~three-beam~~ three-beams cross talk canceling using the sub-beams L1, L2 is used practically, a following problem exists. If the main beam L1 and the sub-beams L1, L2 are arranged in a line perpendicular to the tracks, the apparatus shown in Fig. 1 can be used with no problems. However, when the main beam L1 and the sub-beams L1, L2 are arranged in a line perpendicular to the tracks, the distances between the beams are generally the track pitch, so that it is difficult to separate them from each other by the photodetector. Then, the sub-beams are arranged in a line crossing the tracks obliquely, while being ~~separating~~ separated sufficiently from each other in the tangential direction of the tracks. In this case, reproduction signals due to the beams have time differences in correspondence to the distances in the tangential direction.

Please amend the paragraph beginning at page 16, line 18, as follows:

This embodiment solves the above problem of time difference correction in a different way. Time differences between the beams are detected and corrected precisely for an optical disk having general formats, such as compact disk and DVD.

Please amend the paragraph beginning at page 16, line 23, as follows:

Fig. 7 shows an optical disk apparatus according to the third embodiment of the invention. Three beams, main beam L0 and sub-beams L1, L2, illuminate tracks T0, T1, T2 formed in an optical disk 100, and reflection lights thereof are received by photo-elements 5g, 5e and 5f in the photodetector ~~200~~ 500 to be converted to electrical signals. The detection signals obtained by the photo-elements 5g, 5e with the main beam and the sub-beam are subjected appropriately to time correction by delay elements 300 and 301. Then, the detection signals obtained by the three beams are subjected to cross talk calculation by a calculator 33 for addition and subtraction (in correspondence to the adder 13 and the subtractor 14) to delete cross talk components due to the adjacent tracks. If the time differences are not corrected perfectly by the delay elements 300 and 201, the cross talk components are not deleted completely. Further, if the time error is large, components due to adjacent tracks are added on, and the signal-to-noise ration of reproduction signals becomes even worse~~ reversely~~.

Please amend the paragraph beginning at page 17, line 18, as follows:

In this embodiment, the time difference correction is performed by using frame marks formed beforehand ~~in~~ with equal distances between them along tracks in an optical disk. A frame is a unit of recorded information in an optical disk, and a frame mark is formed at the top of a frame in a way so as to be discriminated easily from other marks on information. For example, a frame mark is formed for each 1,456 bits in a DVD, and it has a length of 14T (where T denotes channel bit length) in contrast to 3T to 11T of the other information. Therefore, if the frame mark can be detected, time errors of the beams can be detected and corrected according to the difference of the timings at which frame marks are detected. However, though the frame marks are formed at equal bit distances, ~~it is~~ they are not necessarily aligned in a direction perpendicular to the tracks. In order to align the frame marks in a direction perpendicular to the tracks, the same number of information pits per one circle of track have to be formed for every track (so-called constant angular velocity recording). However, for a DVD or CD, information is recorded with constant line velocity recording. Thus, the bit number in one track is different according to the position in the radial direction.

Please amend the paragraph beginning at page 18, line 16, as follows:

The time correction by using frame marks is explained further with reference to Figs 7 and 8. In a situation shown in Fig. 8, the main beam L0 is tracking a track T2, while the sub-beam L1 scans a track T0. Along the track T0, an information mark group 103, a frame ~~marks~~ mark 101, an information mark group 104 and a frame mark 102 are formed. For example, in a DVD, the information mark groups 103, 104 are composed of random data of mark lengths of 3T to 11T. On the other hand, the frame ~~mark~~ marks 101, ~~103~~ 102 ~~includes~~ include a mark of length of 14T not included in the information mark groups. In Fig. 7, a signal selector 40 selects reproduction signal S0, S1, S2 from the photodetectors in correspondence the beams to be supplied via a binarizer circuit 50 to a frame mark detector 60. The frame mark detector 60 detects a frame mark. For example, it counts the mark length of every signal sequence in the input signals and outputs a pulse signal when a mark length of 14T is detected. When the main beam L0 tracks the track T2, or when the sub-beam L1 tracks the track T0, as shown in Fig. 8, the signal selector 40 selects the reproduction signal due to the sub-beam L1. Therefore, when the sub-beam L1 scans the frame mark 101, the frame mark detector 60 detects it and outputs a detection pulse FP. For ~~the~~ brevity of explanation, selection of reproduction signal S2 by the sub-beam L2 is omitted in Fig. 8.

Please amend the paragraph beginning at page 19, line 17, as follows:

Once reproduction signal D101 due to a frame mark 101 is detected, a mark distance measuring device 70 is activated to count a time until another reproduction signal D102 due to a next frame mark 102 is detected. As shown in Fig. ~~1~~7, the mark distance measuring device 70 is composed of flip flops 700, 701, gates 702, 703 and a counter 704. When the first frame mark detection pulse FP (D101) is detected, the outputs of the flip flops 700 and 701 become H level and L level, so that the frame mark detection pulse passes the gate 702 to supply a start pulse CSTRT which starts the counter ~~701~~ 704. The start pulse CSTRT is also sent to ~~the~~ a track jump driver 111 which makes a tracking actuator 204 perform track jump by moving an object lens 203. Then, as shown in Fig. 8, the main beam L0 is jumped from track T2 to track T0. Further, start pulse CSTRT is also sent to a switch controller 120, which controls the signal selector 40 to ~~changes~~ change the

reproduction signal S1 due to the sub-beam L1 to the reproduction signal SO due to the main beam L0.

Please amend the paragraph beginning at page 20, line 17, as follows:

On the other hand, because the frame marks 101 and 102 are provided at the predetermined constant distance, if they are reproduced continuously with the same beam without track jump, a count of predetermined value of M will be obtained surely. For example, for a DVD, M = 1456 surely when the distance is measured with <u>the</u> channel clock.

Please amend the paragraph beginning at page 20, line 23, as follows:

By comparing the count N obtained by the mark distance measuring device 70 with the count M, a subtractor 80 determines <u>the</u> time difference between the reproduction signals of the two beams. Time delays are given by the delay means 300 and 301 to the reproduction signals S0 and S1. If the time delays are appropriate or if the time difference in correspondence to the distance in tangential direction for the main beam S0 and the sub-beam S1 is corrected perfectly, the count N is surely equal to the value M. In other words, the error (N - M) between the count N and the value M represents correction error on time correction between the beams. The value M is stored in a register 90.

Please amend the paragraph beginning at page 21, line 11, as follows:

A delay corrector 110 sets delay quantities to the delay means 300, 301 so that the error (N-M) obtained by the subtractor 80 becomes zero. Fig. 9 shows an example of the delay corrector 110. An output signal of the photo-element 5g in the photodetector 200 is converted to a digital signal by an analog-to-digital converter 300a. Then, it is converted by a shift register 300b to give a delay for each clock period successively at the rising edge of clock signal CLK. A selector 300c selects one of the output of registers in the shift register 300b, and a digital-to-analog converter 300d converts it again to an analog signal as reproduction signal S0. Thus, <u>the</u> delay quantity is changed in the unit of one clock period in the delay means 300. The other delay means 301 is constructed similarly.

Please amend the paragraph beginning at page 22, line 1, as follows:

The time correction between the main beam L0 and the sub-beam L1 is explained above. Further, time correction between the main beam L0 and the sub-beam L2 may be performed similarly. For example, after the abovementioned processing is completed, the flip flops 700, 701 and the counter 704 in the mark distance measuring device 70 are reset. Then, after ~~a~~ the frame mark 101 is reproduced with the sub-beam L2, track jump is performed, and ~~a~~ the frame mark 102 is reproduced with the ~~sub-beam~~ main beam L0. Then, the delay quantities are set to the delay means 300, 301 so that the difference between the count M and the value N becomes zero. The delay quantity is set again to the delay element 301 because the relative delay quantity for the delay means 300, 301 determined above have to be kept.

Please amend the paragraph beginning at page 22, line 15, as follows:

When the delay quantities to the delay means 300 and 301 are set appropriately for the main beam L0 and the sub-beams L1, L2, cross talk is deleted appropriately by the calculator 33 for addition and subtraction. The signal after cross talk canceling is supplied via a binarizer circuit 21 to a phase lock loop (PLL) circuit 22. Then, data component DATA and clock signals CLK are separated, and the data are supplied to a circuit at a later stage, such as a digital video decoder.

Please amend the paragraph beginning at page 23, line 6, as follows:

The PLL clock signals are also supplied to the delay means 300 and 301 according to following reasons. The optical disk apparatus corrects position errors of the main beam L0 and the sub-beams L1, L2 in the tangential direction of the tracks. Even if optimum delay quantities for the delay means 300 and 301 are determined, a condition has to be satisfied that the reproduction speed of signals is constant. When the speed of reproduction signal is changed for example due to a change in revolution of optical disk 100, the optimum delay quantities have to be set again according to the change. The above-mentioned time difference correction may be performed at that time, but while time difference correction is performed, information cannot be reproduced and this is a loss time which worsens the performance of the entire system ~~much~~. Then, in the apparatus, the time difference is measured in the unit of the clock period, and the delay quantities for the delay means 300

and 301 are changed in proportion to the speed of reproduction signals. The PLL circuit 22 generates clock signals in synchronization on frequency with the reproduction signals inherently. Further, as mentioned above, the delay means 300, 301 ~~is~~ are constructed as shown in Fig. 9 to give delay in the unit of the clock period. Then as far as the PLL circuit 22 is operated, the delay quantity is changed according to the speed o the reproduction signal. In other words, once the time difference correction is performed at a reproduction speed while the PLL circuit 22 is operated, cross talk canceling can be performed always at the optimum state even if the reproduction speed is changed.

Please amend the paragraph beginning at page 25, line 1, as follows:

Further, when a beam passes across an area between tracks without recorded information during a ~~while~~ track jump, disturbances in the PLL circuit 22 due to noises are liable to occur. Further, noises similar to a frame mark may appear. Therefore, it is favorable in a track jump period to generate a hold pulse (HOLD) by the track jump driver 111 to stop the PLL circuit 22 and the frame mark detector 60 temporarily.

Please amend the paragraph beginning at page 25, line 9, as follows:

As explained above, the time difference between the beams can be corrected precisely by detecting frame marks formed at the same distance along the same track. That is, by reproducing the frame marks by the two beams while repeating track jump, the delay quantity is corrected according to a measured distance between the frame marks and the frame mark distance determined in the format of the optical disk. Because the time difference between the beams is ~~precisely~~ precise, the cross talk canceling can always be performed optimally.

Please amend the paragraph beginning at page 25, line 29, as follows:

Further, by using the shift register 300b synchronized with the PLL clock signals for the delay means, even when the reproduction speed is changed, the time difference can be given always with the optimum correction quantity. Therefore, cross talk canceling can be realized ~~stable~~ stably and at high precision.

Please amend the paragraph beginning at page 25, line 25, as follows:

Though tracking is always performed with the main beam L0 in this embodiment, but it may be performed with the sub-beam L1, L2. For example, the tracking is performed on a beam reproducing the track T0 among the main and sub-beams. This is favorable when the sub-beam is not above the adjacent track (for example when it is near the main beam somewhat).

Please amend the paragraph beginning at page 26, line 7, as follows:

The counter 703 is operated with the PLL clock signals in the apparatus. However, the clock signals for the counter ~~is~~ are not necessarily synchronous with the reproduction signals as far as the frame mark distance is represented uniquely. For example, before starting the time difference correction, the frame mark distance is measured with the same beam on the same track, and the measured value is stored as the value M in the register ~~9~~ 90.

Please amend the paragraph beginning at page 26, line 20, as follows:

In this apparatus, after the frame mark 101 is detected with the sub-beam L1, track jump is performed, and the frame mark ~~103~~ 102 is detected with the main beam L0. However, the processing may be started from the main beam L0 within the spirit of the time difference correction in this embodiment.